USS Monitor Survey:

3-D Sonar and Navigation Processing

31 August 1990

W. Kenneth Stewart and Stephen R. Gegg

Deep Submergence Laboratory
Woods Hole Oceanographic Institution
Woods Hole, MA 02543

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) USS MONITOR survey: 3-D sonar and navigation processing		5. TYPE OF REPORT & PERIOD COVERED Technical 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Stewart, W. Kenneth and Stephen R. Gegg		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Woods Hole Oceanographic Institution Woods Hole, MA 02542		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Arlington, VA 22217		12. REPORT DATE 31 Aug 1990 13. NUMBER OF PAGES 38 p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

In citing this report in a bibliography the reference given should be to: Woods Hole Oceanographic Institution, unpublished Technical Report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

1) Shipwrecks
2) Underwater surveys
3) Sonar
4) MONITOR Marine Sanctuary Program
5) ROV DEEP DRONE
6) USS MONITOR

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

See reverse side.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. As part of the 1987 expedition to the USS MONITOR wreck site, conducted by the National Oceangraphic and Atmospheric Administration and the U.S. Navy, the Deep Submergence laboratory undertook a three-dimensional sonar survey of the sunken ship. A downward-looking, mechanically-scanned profiling sonar (Mesotech 971) was mounted on the Navy's DEEP DRONE ROV, which was fitted with a good quality attitude measurement package. A real-time processor collected data from the sonar, from an external long-baseline system, and from the attitude package.

While on site, the measurements were filtered and merged to form a composite depth map of the survey area. Later postprocessing of the survey data was undertaken on a research basis, as part of a program for developing real-time survey techniques. A discrete, steady-state Kalman filter was used to estimate position and attitude for real-time processing. Though smoothing can produce better results, all post-cruise modeling used the same technique to simulate real-time performance. Appendices detail the record formats and catalogue of digital data, and give a description of hardcopy products.

Table of Contents

USS Monitor Survey:

3-D Sonar and Navigation Processing

31 August 1990

W. Kenneth Stewart and Stephen R. Gegg

Deep Submergence Laboratory
Woods Hole Oceanographic Institution

Introduction

As part of the 1987 expedition to the *USS Monitor* wreck site, conducted by the National Oceanographic and Atmospheric Administration and the U.S. Navy, the Deep Submergence Laboratory undertook a three-dimensional sonar survey of the sunken ship. A downward-looking, mechanically-scanned profiling sonar (Mesotech 971) was mounted on the Navy's *Deep Drone* ROV, which was fitted with a good quality attitude measurement package (Figure 1). A real-time processor collected data from the sonar, from an external long-baseline system, and from the attitude package.

While on site, the measurements were filtered and merged to form a composite depth map of the survey area. Later postprocessing of the survey data was undertaken on a research basis, as part of a program for developing real-time survey techniques. A discrete, steady-state Kalman filter was used to estimate position and attitude for real-time processing. Though smoothing can produce better results, all post-cruise modeling used the same technique to simulate real-time performance.

To improve the fidelity of 3-D sonar maps, a new processing effort was undertaken. Improvements include renavigation, better attitude compensation, and enhanced 3-D modeling algorithms. This report describes the equipment and techniques employed during the 1987 survey, the original calibration and modeling algorithms, and the enhanced techniques used in final processing. Appendices detail the record formats and catalogue of digital data, and give a description of hardcopy products.

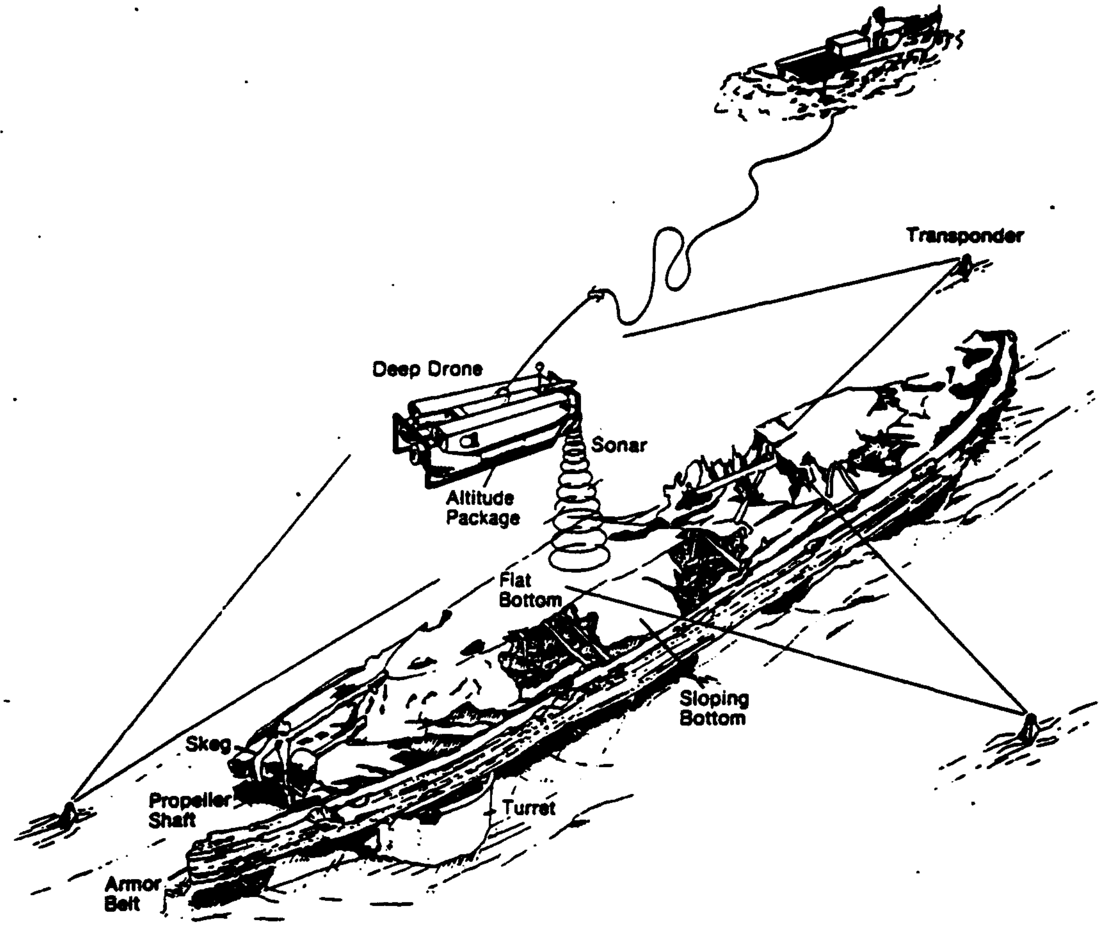

Figure 1: Survey Configuration

Sonar Survey

As a means of testing new techniques then under development, the Deep Submergence Laboratory (DSL) of the Woods Hole Oceanographic Institution undertook a sonar survey of the *USS Monitor* wreck site. The DSL effort was a component of a more comprehensive program conducted by the National Oceanographic and Atmospheric Administration and the US Navy. The goal of the sonar survey was to generate a three-dimensional model of the survey area, from which quantitative measurements could be extracted and used to characterize the shape and orientation of the sunken shipwreck. The following sections describe the instrumentation used in the survey, calibration, and survey procedures.

Instrumentation

The primary components of the sonar-survey system were the platform itself—the Navy's *Deep Drone*—a remotely operated vehicle (ROV); an acoustic long-baseline navigation system; a high-resolution attitude-measurement package; a profiling sonar; and real-time processors for data acquisition, logging, sonar modeling, and display. Brief descriptions of the five components are presented here; later sections describe instrument calibration, survey data acquisition, and sensor processing algorithms.

Deep Drone: The Deep Drone is a tethered, unmanned ROV maintained and operated by Eastport International on behalf of the US Navy Supervisor of Salvage. The vehicle is controlled from the surface by an operator receiving feedback from several on-board cameras and an external navigation system. The ROV's hydraulic thrusters provide four-degree-of-freedom control: longitudinal, lateral, and vertical translations; and yaw, or rotation about the vertical axis. The *Deep Drone* is essentially a subsea platform designed to carry different cameras and sensor subsystems, or a manipulator for work and recovery.

Navigation: The navigation system used for the survey was an Oceano acoustic-transponder system. Operating at frequencies around 56-KHz, a long-baseline transponder network was emplaced around the vehicle on fixed tripod mounts; these were interrogated by a transponder located on the forward portion of the vehicle. Round-trip slant ranges were extracted by the surface signal processor, net-relative positions were computed, transformed to a true-North coordinate frame, and logged by the Oceano system. Processed coordinates were transferred to Eastport's ALNAV system for additional filtering and display.

Attitude: A high-precision attitude package, designed and developed by DSL, was mounted on the ROV to provide precision measurements of pitch, roll, yaw, and pressure depth. The self-contained unit comprised: pitch and roll inclinometers, pitch- and roll-rate sensors, a flux-gate compass for absolute heading reference, a strap-down gyro for yaw rate, a three-axis accelerometer, and a precision pressure transducer. An on-board microprocessor digitized the analog signals coming from the sensors at a 10-Hz sampling rate and transferred the data to the surface over a serial communications link.

Sonar: The primary sensor used for the survey was a Mesotech 971 scanning sonar. This is a high-frequency, mechanically-scanned device with a range resolution of less than a centimeter. In profile mode, the 675-kHz, 1.5°-beam-width system returned a thresholded range along with transducer scan position. Threshold and gain were adjustable at the surface processor. Most surveys were conducted using the 5-m range scale, and occasionally 10-m. Slant range and scan positions were transmitted over a serial link at the conclusion of each ping cycle at about 5-10 Hz, depending on the range and scanning resolution selected.

Real-Time Processors: Data streams from the ALNAV processor, attitude package, and Mesotech sonar were transferred over RS-232C serial communications channels to the DSL data-acquisition and logging system. The real-time processor consisted of an Intel MultiBus computer with additional data-acquisition and communications boards. Custom software developed at DSL operated under the VRTX real-time multitasking executive. The sensor data streams were merged, filtered, and recorded on hard disk for later transfer to floppies. The processed stream was also buffered, then transferred over a serial link to a Sun Unix workstation for final processing and graphic display.

Calibration

To ensure highest quality results, the attitude package was thoroughly calibrated before commencing the survey. The inclinometers and accelerometers were first bench-tested and aligned with respect to a common axis to minimize zero offsets at their final mounting positions in the attitude-package electronics chassis. The chassis was then positioned over a range of precisely known positions, and a series of digital measurements were recorded at each position by the data logging system. This technique ensured that gains and offsets in the A/D converters were included in the final calibration results.

From this series, measurements were averaged at each calibration point. The averaged measurements were then used to derive a zero offset and gain factor for each sensor. Measurements showed good linearity over the expected operating range, so nonlinear calibration curves were not derived. A similar calibration was performed for the pressure sensor using a precision drop-weight tester. A maximum resolution corresponding to 5 cm of seawater for the pressure gage and about 0.1 degrees for the pitch and roll sensors was determined by the sampling resolution on the system A/D's.

The yaw-rate gyro was calibrated by suspending the chassis from a swiveled mount and rotating the chassis at various uniform rates in both directions. Absolute heading reference came from the flux-gate compass. By averaging over several rotations, a gain factor was obtained for the heading rate; zero offset was taken at rest. Clockwise and counterclockwise response was slightly asymmetric, so different gains were calculated for each direction.

The chassis was then installed in the cylindrical pressure housing and zeroed in pitch and roll. Marks were inscribed on the housing end caps and cylinder to ensure consistent mating, and for final alignment with the vehicle and sonar. When installed in the field, the package was first nominally aligned with the vehicle using the scribed marks. The sonar was then put through its self-calibration procedure, which determined scanning hysteresis and zero point, where it came to rest. The sonar scanning assembly was then brought into alignment with the attitude package and secured. This procedure ensured that the attitude measurements would be made relative to the sonar transducer itself. Finally, offsets were measured for the attitude package and sonar transducer using the ROV's navigation transponder as the origin of a local coordinate system.

The heading-calibration process was completed at depth with all systems in an operational configuration. Since the magnetic-field gradient sensed by the flux-gate compass is disturbed by the vehicle (and by the attitude package itself), a cancellation procedure was carried out. This entailed spinning the vehicle in both directions through several turns and collecting data from compass and gyro. Average gyro drift was first calculated by comparing the integrated rate measurements against unit rotations (multiples of 360°) with respect to a fixed, arbitrary direction measured by the compass. The drift-corrected gyro headings were then used to determine flux-gate deviation over the 360° range. Clockwise and counterclockwise calibration cycles were averaged to compensate for the rotational lag in compass measurements.

The zero offset of the compass was later determined from data taken during the survey. Vehicle headings relative to the acoustic net were computed from successive navigation fixes, compared with the deviation-corrected compass measurements, and averaged over long periods and multiple directions of travel. Data were selected from near-slack water periods to minimize the bias from vehicle crabbing against strong currents. The final result of this process was the off-

set between zero heading as measured by the compass and assumed North in the long-baseline coordinate frame. With this approach local magnetic variation and flux-gate zero offset were not considered, and all positions and headings were measured with respect to the acoustic-navigation coordinate frame.

Because the ROV was operating at roughly the same depth as the long-baseline net, the geometry was poor for obtaining vertical position measurements from the acoustic system and pressure readings were used exclusively. The final part of the calibration process was to reduce the influence of tidal variations (about 1 m locally) on the pressure transducer. During the survey, the vehicle was returned to the same spot (a camera calibration target emplaced at the start of the survey) at intervals of about 1 hr. The vehicle was situated on the bottom and pressure readings recorded for a 1-min interval. During postprocessing, these measurements were averaged over the survey period, referenced to mean sea level, interpolated between calibration points, and applied to the data to correct for tidal variation.

Data Collection

The majority of data used in the sonar modeling was collected during dives 19-22, as a component of the photomosaic coverage. This consisted of three sets of tracklines designed to provide full, overlapping coverage for the camera systems. With the sonar oriented to scan downward and perpendicular to the vehicle track, a 30° scanning sector was selected to offer slightly overlapping sonar coverage as well. One set of tracks was oriented roughly along the axis of the ship, bearing approximately 105°. The other two sets were roughly transverse to the ship's axis, bearing about 45°. These tracks were oriented parallel to the prevailing currents, roughly from the Southwest, to facilitate driving the ROV smoothly along straight lines.

Other sonar data were collected during a structural survey of the shipwreck and during a horizontal stereo-photography sequence along the sides of the wreck. These data were not used in final processing because of the relatively poor navigation available. During some periods, shadowing by the wreck and self-shadowing because of the ROV transponder's mounting configuration degraded navigation significantly. Straight, constant-velocity runs were also preferred because of the improved filtering that could be applied.

As described in an earlier section, real-time data were acquired by the DSL data logger from the ALNAV navigation system, DSL attitude package, and Mesotech sonar. Data files generally began at the start of a line and were segmented into files with a maximum size of 360 kBytes to facilitate transfer to floppy disks. Files were numbered sequentially from the beginning of the sonar-data collection period and do not correspond to the track-line numbering scheme used for other data (see Appendices B and F). The DSL data-logger time base was synchronized with the ALNAV clock, though, and all records are time stamped.

Initial processing of the data stream took place in the real-time computer. This consisted entirely of converting A/D machine units to engineering quantities (degrees, meters, etc.) by applying calibration offsets and conversion factors. All data were logged by the DSL system in this semi-raw form so that original data values could be recovered in case calibration factors or processing algorithms were modified. Unfiltered, calculated positions from the Oceano long-baseline processor were also recorded separately. Unfortunately, the raw slant-range measurements were not preserved. This precludes more sophisticated postprocessing of navigation data to extract higher quality results.

On-site and Preliminary Processing

On-site and shore-based postprocessing was undertaken on a separate Unix-based workstation from Sun Microsystems. Data were transferred from the logging processor over a serial communications link, and sonar tracks were displayed in real time as an indicator of survey progress and sonar coverage attained. Three-dimensional processing was performed off-line at the conclusion of the survey, and preliminary results were achieved on site. This section briefly describes the earlier processing techniques; a more detailed description of algorithms used then and in final processing is given in the following sections.

Preliminary processing on the individual sensor streams included the application of calibration data as described earlier. Tidal corrections and compass offset were computed from the full data set. Next, position and attitude data were filtered to reject flyers then processed with a discrete, steady-state Kalman filter. This is an optimal estimator often used for real-time processing. Though smoothing can produce better results, all preliminary modeling used the same technique to simulate real-time performance. Since a model of the vehicle dynamics was unavailable, the simple filter uses a constant velocity assumption for all parameters. This is reasonable for heading and for vehicle translations since the survey data used in sonar processing consists mainly of straight-line tracks. However, for oscillatory motions in pitch and roll or for abrupt changes in vehicle trajectory, there is some overshoot in the estimates.

Sonar modeling employed a novel technique developed at DSL in which overlapping and redundant data are combined in a three-dimensional probability model before final shape estimates are extracted. In this manner, accuracy and resolution of the model are enhanced. As a final modeling step, a surface estimate, or depth map, is extracted from the probability distribution.To fill in gaps, the composite, two-dimensional surface map was extrapolated with an iterative dilation algorithm.

Noisy patches over and around the wreck were visible in the map, mainly caused by the abundant schools of fish that inhabit the "artificial reef" (swim bladders are good sonar reflectors). To mitigate this effect, the extrapolated map was segmented into the ship and seafloor using a depth threshold; suspected fish noise was interactively removed with localized median filters; and the two segments were filtered with a convolution mask before being remerged. From this resulting model various products were produced, including color and gray-scale contour maps, and three-dimensional perspective views of the site.

Final Postprocessing

To produce the highest quality results from the 1987 sonar data, a second processing effort was undertaken. Rather than being an extension of real-time techniques, new algorithms were developed along with an application of newer techniques developed over the intervening years. This new processing focused mainly on those areas where the highest payback in data quality was expected. Navigation was perceived as the greatest determinant. Although the original acoustic navigation was very good in relation to industry standards, residual inaccuracies were the main limitation to higher modeling fidelity. The quality of attitude data was also enhanced by additional smoothing, and more accurate rotational transforms were applied. Finally, new modeling algorithms were developed to mitigate fish noise; these techniques were applied directly to the 3-D probability model rather than to the deterministic surface map.

Navigation

The purpose of reprocessing the *Monitor* navigation data set, was to take advantage of improved and more sophisticated processing techniques developed at DSL since the initial processing effort in 1987. Navigation processing improvements, particularly those in the area of long-baseline acoustics, have been implemented based on experience gained from both large-scale seafloor mapping and fine-scale surveying efforts, such as the JASON Project. Recent data sets have shown the advantage of the more precise navigation produced by these techniques, especially for complex image processing and mosaicking. Considering the desired end product for the *Monitor* data, it was felt that reprocessing the original navigation with the new procedures would contribute significantly to the overall modeling effort.

A brief effort was undertaken to compare the DSL real-time navigation with the unprocessed Oceano navigation, the Oceano "filtered" navigation, and the final navigation produced by the present DSL processing scheme. Dive #22 was chosen for this effort because it provided a convenient link between the line-numbering designations used for the sonar processing and the line numbering in place during original data collection. This assured that identical data sets were being compared. The results of this effort, Figures 2-5, indicate that the best approach is to start with the unfiltered Oceano navigation and carry out the reprocessing using the DSL scheme. This eliminates any "biasing" of the data introduced by other smoothing techniques applied prior to the reprocessing. A more detailed comparison of the different renavigation techniques applied to one line from dive #19 is shown in Figure 6.

The unfiltered Oceano navigation files for dives #19, #20, #21 and #22 were converted to DSL's PNS (Platform Navigation Status) format to begin the processing (see also Appendix E). Data bracketing the start and end times of the sonar lines by +- 15 seconds were then extracted from these files on a line-by-line basis for reprocessing with the DSL techniques. First, the data were examined for spurious, or "wild", point data, which were removed with a median filter. This random, spurious noise in long-baseline acoustics is common and is usually attributable to two primary sources: (1) acoustic interference with the returns from the transponders caused either by ship, vehicle, or sea-state noise resulting in erroneous readings, or (2) from loss of the direct return due to shadowing of a transponder(s), by topography, or in the case of large wreck relief and low-altitude ROV maneuvering, shadowing by the wreck itself.

Once the lines had been median filtered, a Gaussian convolution mask was applied to smooth the data. This was an iterative procedure at first, with the results of the various smoothing weights compared to the final processed sonar results to determine an optimum setting for the filter. This is necessary because of the potential high maneuverability of an ROV, which can result in abrupt trackline changes. The smoothed navigation data files were then remerged with the sonar and attitude data for sonar modeling. It should be noted that during the navigation reprocessing no adjustments were made to transponder locations and that the coordinate frame of the reprocessed navigation is identical to that of all other navigation from the expedition.

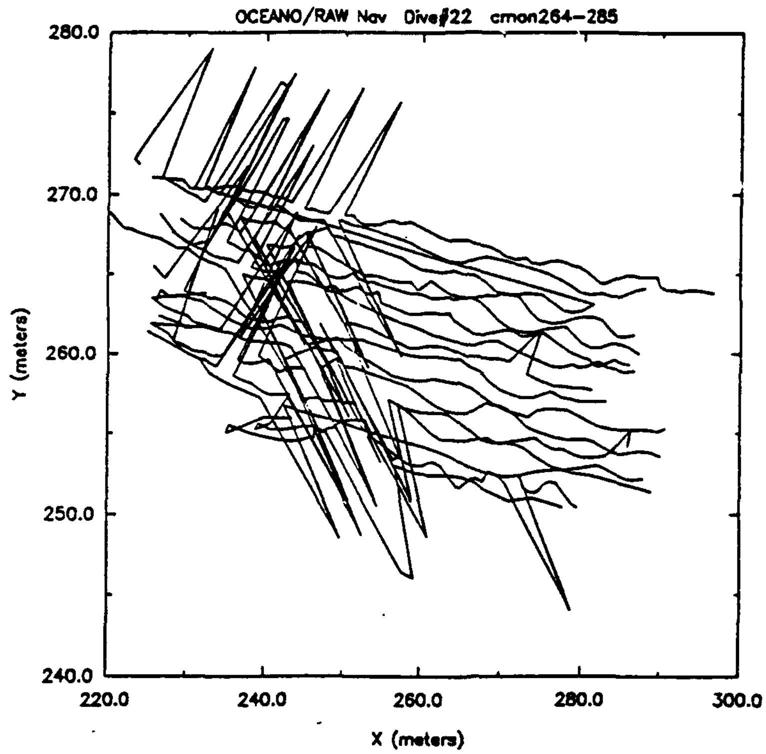

Figure 2: Unfiltered Oceano Navigation

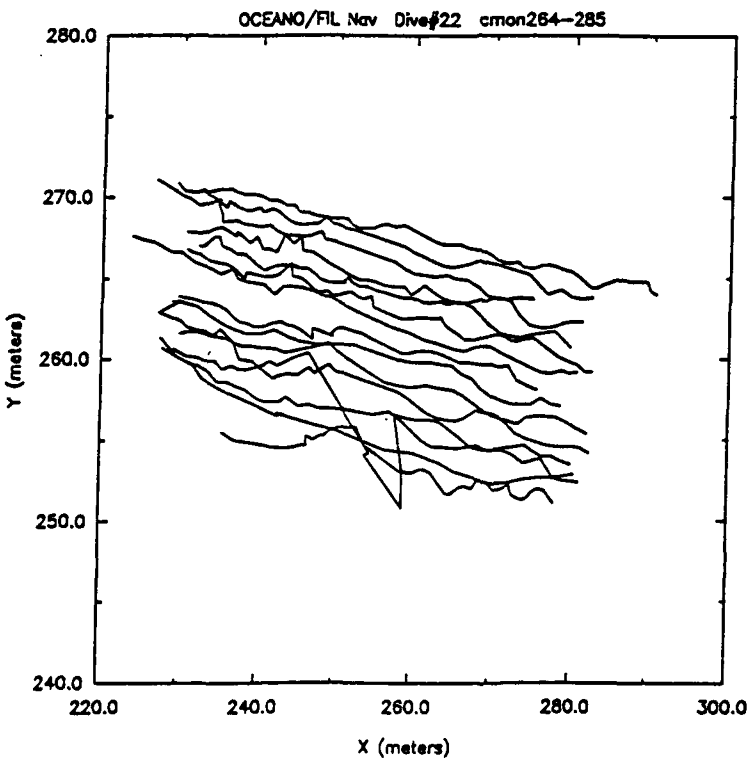

Figure 3: Filtered Oceano Navigation

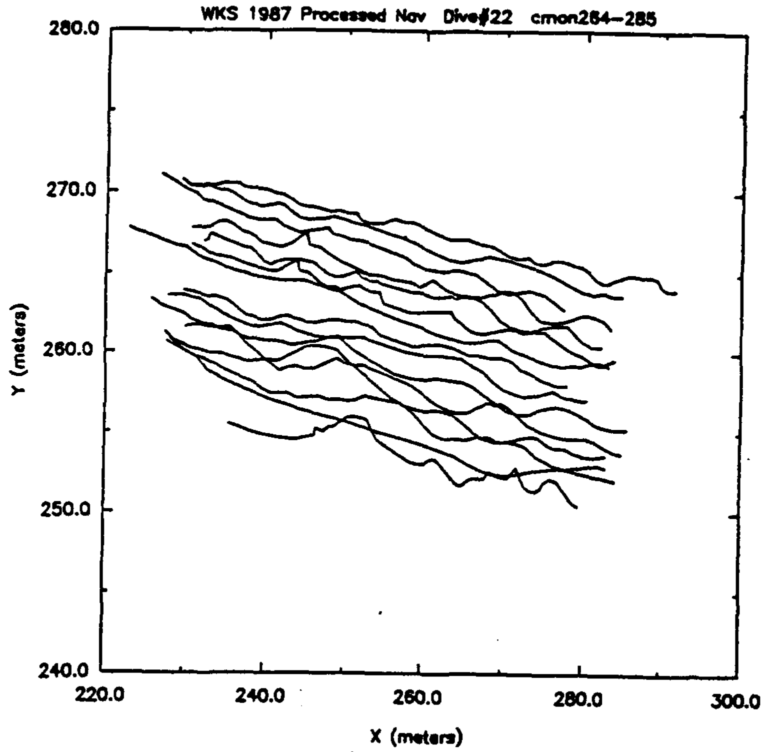

Figure 4: DSL Real-time Navigation

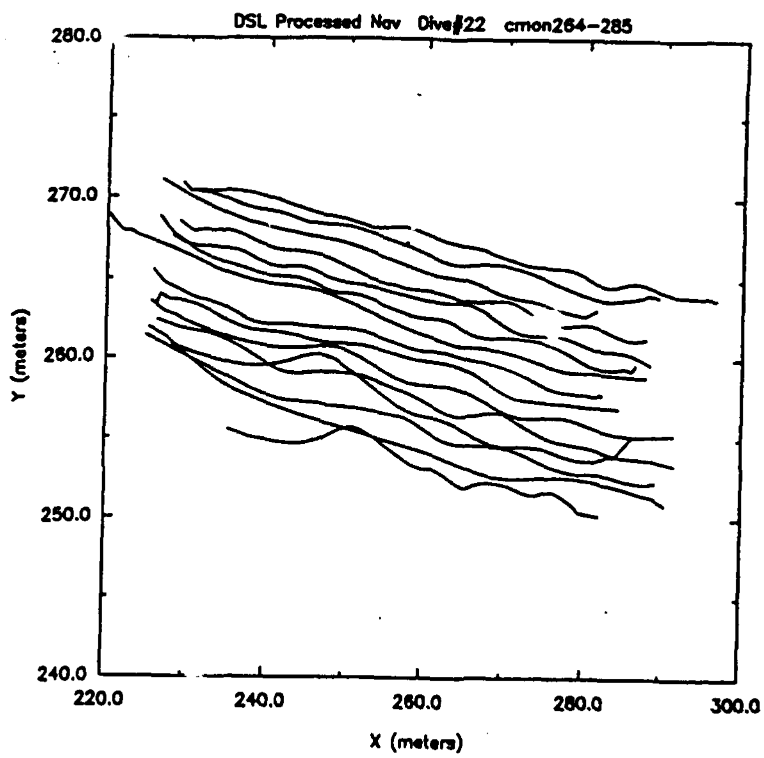

Figure 5: DSL Final Navigation

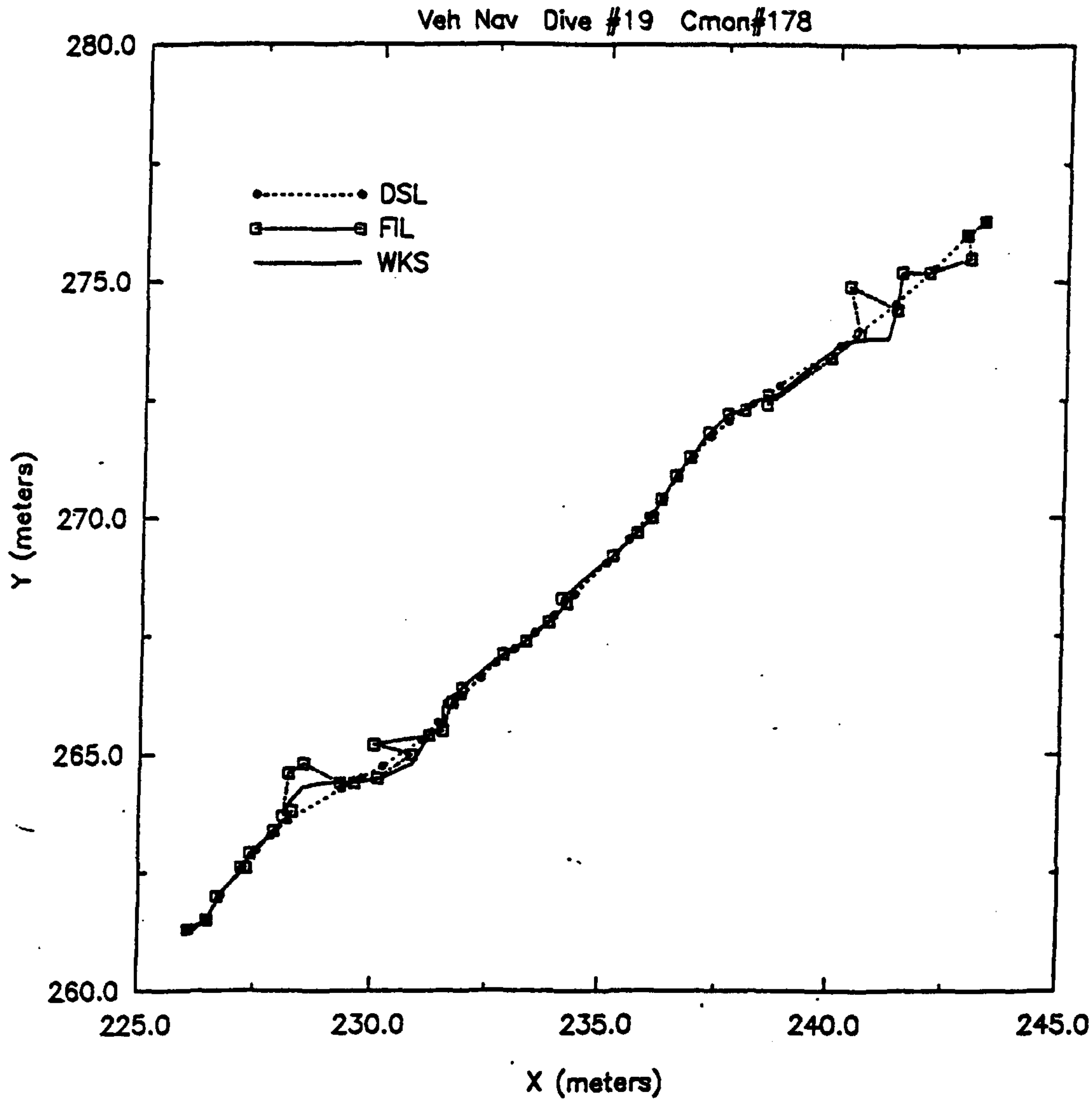

Figure 6: Comparison of Navigation Processing Techniques

Attitude

Reprocessing of the attitude data was very similar to that applied to the navigation. A median filter was not used, however, since the original data had already been stripped of flyers (these were caused mainly by communications errors in the serial link). A light Gaussian filter was applied to smooth any remaining random noise. A second step was to reformulate the rotational attitude transformation. The original processing used small-angle approximations, which were quite reasonable over most of the operating range for pitch and roll. At large excursions from the ship, or when operating in strong currents, however, the ROV was disturbed by tether forces and assumed pitch angles greater than 20°. The new formulation used a precise matrix formulation and was applied in all subsequent processing. These two steps led to some improvement in data quality, however, navigation remained the strongest determinant of modeling fidelity.

Stochastic Modeling

The fundamental modeling algorithm used in preliminary and final processing of the *Monitor* sonar data is a three-dimensional technique described more fully in previous publications [*Stewart*, 1987a, b, 1988a, b]. The basis of this approach is to form a model as a three-dimensional spatial decomposition of cubical volume elements, or voxels. Associated with each voxel is a probability measure that represents the properties within the small region. As new sensor information is acquired, it is merged using a technique we call *stochastic backprojection*; this is derived from an incremental adaptation of the summation method for image reconstruction. Error and ambiguity are accounted for by blurring a spatial projection of remote-sensor data before combining it stochastically with the model.

By exploiting the redundancy in high-bandwidth sensing, the model's certainty and resolution are incrementally enhanced as more data accumulate. This is in contrast with traditional approaches that rely on extensive postprocessing to eke out information from sparse data sets. Also, by taking advantage of complementary information from different sensors, more complete and more accurate models can be built, with less effort than for an exhaustive analysis of single-sensor data. Modeling results with real systems suggest benefits in large-scale underwater mapping applications—quality of the final product is improved and real-time processing reduces delay and expense in the postprocessing tedium.

Analytically, the global representation can be treated compactly as a state vector, representing our current best estimate of the features being considered (state variables). A volume of space interrogated by a sensor is represented also as a vector that captures the information in independent events. In fact, we view the model building as a recursive process, similar to a Kalman filter. New event vectors are merged stochastically with the model to increase the accuracy, the resolution, and the certainty of our estimate.

Computationally, the models can be treated as sets of feature vectors, ordered according to need. The discrete, cellular partitioning facilitates a numerical approach and permits the use of different data structures to suit the algorithm or hardware base—2-D arrays, 3-D arrays, 3-D arrays of vectors, and vector lists of different kinds. As there is no single data structure or representation to serve all needs, we try to maintain a flexibility and consistency that lets us move between representations as appropriate.

The result of this processing scheme is a three-dimensional distribution reflecting the most probable surfaces in the survey area—seafloor bathymetry and surface shape of the shipwreck itself. In earlier processing, a deterministic depth map was extracted and filtered two-dimensionally to achieve the final results. A problem with this approach is that sonar returns from the dense fish population over the wreck often obscured underlying features of the ship. To mitigate this problem, new algorithms were developed that operate in 3-D probability space before a deterministic surface estimate is made.

The first step was to apply a 3-D erosion algorithm to the model. This is a morphological operator that shrinks small features and linear endpoints by iteratively removing voxels that satisfy the erosion criteria. Second, a 3-D connectivity analysis was performed to segment the probability model into contiguous objects. A threshold was determined based on object size and probability values, and connected regions failing the threshold test were culled. The outcome was to remove

small, isolated regions that were likely to be fish. This method was highly effective for all but the largest clusters of fish. By setting the threshold high enough to remove these clusters, valid portions of the ship and seafloor would also have been culled.

At this stage we resorted to hand editing of the probability model to remove all remaining features suspected to be fish clusters. This technique was aided by volumetric visualization software that allowed interactive editing in selected regions of the model. The edited model was then eroded and culled a second time to remove any "fragments" created by the editing process. The culling process was followed by a 3-D dilation, the morphological inverse of an erosion; nearest neighbors of boundary voxels meeting the dilation criteria are set to an intermediate probability value. The result is that small gaps in the model are filled, and adjacent regions are connected.

The next step was to extract a deterministic surface estimate from the probability distribution. On a column-by-column basis, a depth value is computed as the first moment of probability values exceeding a certain threshold. In essence, this is a weighted average that considers overlapping and redundant sonar returns, and has the effect of smoothing any remaining noise in the model (mainly navigation error). The result is a two-dimensional array of depth values over the region of sonar coverage.

The final processes applied to the depth map were to extrapolate into regions of sparse or nonexistent sonar coverage. The ship and seafloor were first segmented into separate regions using a depth threshold. The seafloor segment was iteratively dilated using a modified 2-D algorithm, then filtered and remerged with the ship segment. It should be noted that other interpolative techniques can produce somewhat better results, but this approach was convenient within the context of our processing environment. The end result of all processing is a fully populated digital array of depth values covering the survey region being considered. From this spatial model various hardcopy products have been produced including color and gray-scale depth images, three-dimensional perspective views, and an animated fly-around of the site.

Recommendations for Future Surveys

At the time of the 1987 expedition, the survey techniques employed can be fairly said to have reflected state of the art. Since then, however, new technology has been developed that should be considered in any follow-on effort of a similar nature. Of most impact to a three-dimensional survey would be improvements in navigation. Specifically, higher frequency acoustic navigation systems are now available with accuracies on the order of a few centimeters. A further improvement in survey quality can be attained with a scanning laser system, newly available for undersea use. The angular resolution of such devices is superior to that of a sonar and, because the scanning rate is not limited by the speed of sound in water, much denser coverage can be achieved.

Acknowledgments

Principal funding for the original work was provided by the Sea Grant Program of the Massachusetts Institute of Technology. Other significant support has come from the *Monitor* Marine Sanctuary Program of the National Oceanic and Atmospheric Administration, from the Office of Naval Research, and from the Deep Submergence Laboratory of the Woods Hole Oceanographic Institution. Final processing of the *Monitor* data was supported by National Center for Marine Preservation Technology of the Maryland Historical Trust.

References

Stewart, W. K., A Non-Deterministic Approach to 3-D Modeling Underwater, in *Proceedings of the Symposium on Unmanned Untethered Submersible Technology*, vol. 1, pp. 283-309, University of New Hampshire, Marine Systems Laboratory, June 1987.

Stewart, W. K., Computer Modeling and Imaging Underwater, *Computers in Science*, vol. 1, no. 3, pp. 22-32, November/December 1987.

Stewart, W. K., A Model-Based Approach to 3-D Imaging and Mapping Underwater, in *Proceedings of the ASME Conference on Offshore Mechanics and Arctic Engineering*, vol. 6, pp. 61-71, Houston, TX, February 1988.

Stewart, W. K., Multisensor Modeling Underwater with Uncertain Information, Ph.D. Thesis, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution, July 1988.

Appendix A: Catalogue of Deliverables

	Quantity
Final Report	
Bound copy	1
Unbound copy (for reproduction)	1
Digital Data Tape (see Appendix B)	1
Processed Navigation Data Diskette (see Appendix D)	1
Gray-scale Hardcopy	
Scaled depth map 18 x 24	1
Scaled depth map 11 x 16	1
Scaled depth map 11 x 14	2
Scaled depth map 5 x 7	2
Color Hardcopy	
Scaled depth map 11 x 16	2
Scaled depth map 11 x 14	2
Unscaled depth map 11 x 14	2
Scaled depth map 8-1/2 x 11	2
Color Transparencies	
Scaled depth map 8-1/2 x 11	2
Color Slides	36
Black and White Negatives	36
Black and White Prints	
Scaled depth map 8 x 10	2
Scaled depth map 5 x 7	2
Animated Videotape	
USS Monitor: The Movie VHS format	1
USS Monitor: The Movie U-MATIC format	1

Appendix B: Contents of Digital Data Tape

./ras total 3872

```
-rw-r--r-- 1 kens 979494 Oct 15 00:49 mon.2.gra.ras
-rw-r--r-- 1 kens 979494 Oct 15 00:49 mon.2.gra.scl.ras
-rw-r--r-- 1 kens 979494 Oct 15 00:50 mon.2.ras
-rw-r--r-- 1 kens 979494 Oct 15 00:50 mon.2.scl.ras
```

./srf total 216

```
-rw-r--r-- 1 kens 206848 Oct 15 00:51 mon.2.srf
```

./FIX total 6749

```
-rw-r--r-- 1 kens 104832 Oct 15 00:52 cmon.178.FIX
-rw-r--r-- 1 kens 200592 Oct 15 00:52 cmon.178a.FIX
-rw-r--r-- 1 kens 34992 Oct 15 00:52 cmon.179.FIX
-rw-r--r-- 1 kens 50940 Oct 15 00:52 cmon.180.FIX
-rw-r--r-- 1 kens 84492 Oct 15 00:52 cmon.182.FIX
-rw-r--r-- 1 kens 44532 Oct 15 00:52 cmon.182a.FIX
-rw-r--r-- 1 kens 87696 Oct 15 00:52 cmon.183.FIX
-rw-r--r-- 1 kens 44640 Oct 15 00:52 cmon.183a.FIX
-rw-r--r-- 1 kens 105660 Oct 15 00:52 cmon.184.FIX
-rw-r--r-- 1 kens 74160 Oct 15 00:52 cmon.191.FIX
-rw-r--r-- 1 kens 35388 Oct 15 00:52 cmon.191a.FIX
-rw-r--r-- 1 kens 59544 Oct 15 00:52 cmon.192.FIX
-rw-r--r-- 1 kens 60408 Oct 15 00:52 cmon.194.FIX
-rw-r--r-- 1 kens 49932 Oct 15 00:52 cmon.194a.FIX
-rw-r--r-- 1 kens 32904 Oct 15 00:52 cmon.197.FIX
-rw-r--r-- 1 kens 73908 Oct 15 00:52 cmon.198.FIX
-rw-r--r-- 1 kens 134820 Oct 15 00:52 cmon.198a.FIX
-rw-r--r-- 1 kens 48420 Oct 15 00:52 cmon.198b.FIX
-rw-r--r-- 1 kens 65016 Oct 15 00:53 cmon.199.FIX
-rw-r--r-- 1 kens 73332 Oct 15 00:53 cmon.200.FIX
-rw-r--r-- 1 kens 71784 Oct 15 00:53 cmon.200a.FIX
-rw-r--r-- 1 kens 61308 Oct 15 00:53 cmon.201.FIX
-rw-r--r-- 1 kens 117108 Oct 15 00:53 cmon.201a.FIX
-rw-r--r-- 1 kens 82728 Oct 15 00:53 cmon.202.FIX
-rw-r--r-- 1 kens 55872 Oct 15 00:53 cmon.205.FIX
-rw-r--r-- 1 kens 77184 Oct 15 00:53 cmon.206.FIX
-rw-r--r-- 1 kens 93600 Oct 15 00:53 cmon.207.FIX
-rw-r--r-- 1 kens 97812 Oct 15 00:53 cmon.208.FIX
-rw-r--r-- 1 kens 58788 Oct 15 00:53 cmon.208a.FIX
-rw-r--r-- 1 kens 70056 Oct 15 00:53 cmon.209.FIX
-rw-r--r-- 1 kens 89172 Oct 15 00:53 cmon.210.FIX
```

```
-rw-r--r-- 1 kens 49068 Oct 15 00:53 cmon.210a.FIX
-rw-r--r-- 1 kens 49176 Oct 15 00:53 cmon.211a.FIX
-rw-r--r-- 1 kens 71892 Oct 15 00:53 cmon.215.FIX
-rw-r--r-- 1 kens 42156 Oct 15 00:53 cmon.215a.FIX
-rw-r--r-- 1 kens 65088 Oct 15 00:53 cmon.216.FIX
-rw-r--r-- 1 kens 91512 Oct 15 00:53 cmon.219.FIX
-rw-r--r-- 1 kens 81864 Oct 15 00:53 cmon.220.FIX
-rw-r--r-- 1 kens 56988 Oct 15 00:53 cmon.221.FIX
-rw-r--r-- 1 kens 19296 Oct 15 00:53 cmon.223.FIX
-rw-r--r-- 1 kens 45612 Oct 15 00:53 cmon.227.FIX
-rw-r--r-- 1 kens 39456 Oct 15 00:53 cmon.228.FIX
-rw-r--r-- 1 kens 153504 Oct 15 00:53 cmon.230.FIX
-rw-r--r-- 1 kens 97164 Oct 15 00:53 cmon.233.FIX
-rw-r--r-- 1 kens 55584 Oct 15 00:53 cmon.234.FIX
-rw-r--r-- 1 kens 122328 Oct 15 00:53 cmon.239.FIX
-rw-r--r-- 1 kens 91260 Oct 15 00:53 cmon.240.FIX
-rw-r--r-- 1 kens 77436 Oct 15 00:53 cmon.241.FIX
-rw-r--r-- 1 kens 60732 Oct 15 00:53 cmon.242.FIX
-rw-r--r-- 1 kens 103788 Oct 15 00:53 cmon.246.FIX
-rw-r--r-- 1 kens 144360 Oct 15 00:53 cmon.248.FIX
-rw-r--r-- 1 kens 97344 Oct 15 00:53 cmon.249.FIX
-rw-r--r-- 1 kens 102960 Oct 15 00:53 cmon.251.FIX
-rw-r--r-- 1 kens 125388 Oct 15 00:53 cmon.252.FIX
-rw-r--r-- 1 kens 117396 Oct 15 00:53 cmon.253.FIX
-rw-r--r-- 1 kens 131076 Oct 15 00:53 cmon.255.FIX
-rw-r--r-- 1 kens 115308 Oct 15 00:53 cmon.257.FIX
-rw-r--r-- 1 kens 165096 Oct 15 00:53 cmon.264.FIX
-rw-r--r-- 1 kens 129240 Oct 15 00:53 cmon.265.FIX
-rw-r--r-- 1 kens 109980 Oct 15 00:54 cmon.266.FIX
-rw-r--r-- 1 kens 124344 Oct 15 00:54 cmon.268.FIX
-rw-r--r-- 1 kens 124848 Oct 15 00:54 cmon.269.FIX
-rw-r--r-- 1 kens 145584 Oct 15 00:54 cmon.270.FIX
-rw-r--r-- 1 kens 127656 Oct 15 00:54 cmon.271.FIX
-rw-r--r-- 1 kens 119412 Oct 15 00:54 cmon.272.FIX
-rw-r--r-- 1 kens 111528 Oct 15 00:54 cmon.273.FIX
-rw-r--r-- 1 kens 122724 Oct 15 00:54 cmon.274.FIX
-rw-r--r-- 1 kens 116280 Oct 15 00:54 cmon.275.FIX
-rw-r--r-- 1 kens 118512 Oct 15 00:54 cmon.276.FIX
-rw-r--r-- 1 kens 112644 Oct 15 00:54 cmon.277.FIX
-rw-r--r-- 1 kens 90180 Oct 15 00:54 cmon.278.FIX
-rw-r--r-- 1 kens 123660 Oct 15 00:54 cmon.279.FIX
-rw-r--r-- 1 kens 59688 Oct 15 00:54 cmon.280.FIX
-rw-r--r-- 1 kens 63648 Oct 15 00:54 cmon.281.FIX
-rw-r--r-- 1 kens 25812 Oct 15 00:54 cmon.285.FIX
```

Appendix C: Digital Data Tape Record Formats

ras

All image files in the ras subdirectory are stored in standard Sun raster format, which is defined by the following C-language structure definition:

```
struct rasterfile {
    int ras_magic;          /* magic number */
    int ras_width;          /* width (pixels) of image */
    int ras_height;         /* height (pixels) of image */
    int ras_depth;          /* depth (1, 8, or 24 bits) of pixel */
    int ras_length;         /* length (bytes) of image */
    int ras_type;           /* type of file; see RT_* below */
    int ras_maptype;        /* type of colormap; see RMT_* below */
    int ras_maplength;      /* length (bytes) of following map */
    /* color map follows for ras_maplength bytes, followed by image */
};
```

srf

The depth map file in the srf subdirectory is a two-dimensional array of unsigned 8-bit depth (z) values ranging from 0 to 255. The size of the array is 512 in the x direction and 404 in the y direction, with the x index varying most rapidly as stored. Scale factors are as follows:

Easting in meters = $0.13861x + 222$

Northing in meters = $0.13861y + 232$

Depth in meters = $0.13861z + 58$

FIX

Merged data files in the FIX subdirectory are stored in a custom format, as fixed-length binary records in IEEE single-precision format, defined by the following C-language structure definition:

```
struct sonrec {
    float t;        /* time in seconds past midnight*/
    float x;        /* x net coordinate in meters */
    float y;        /* y net coordinate in meters */
    float z;        /* pressure depth in meters */
    float p;        /* pitch in degrees */
    float r;        /* roll in degrees */
    float h;        /* heading in degrees*/
    float s;        /* sonar scan angle in degrees */
    float ra;       /* sonar range */
};
```

Appendix D: Contents of Processed Navigation Diskette

```
 Volume in drive B is MONITOR-87
 Directory of  B:\DIVE19

.            <DIR>     10-12-90   9:22p  CMON192  019     1254  10-12-90   8:04p
..           <DIR>     10-12-90   9:22p  CMON194  019     1584  10-12-90   8:04p
CMON178  019      2244  10-12-90   8:04p  CMON194A 019     1541  10-12-90   8:04p
CMON178A 019      5695  10-12-90   8:04p  CMON197  019     1122  10-12-90   8:04p
CMON179  019      1320  10-12-90   8:04p  CMON198  019     2178  10-12-90   8:04p
CMON180  019      1716  10-12-90   8:04p  CMON198A 019     3685  10-12-90   8:04p
CMON182  019      2640  10-12-90   8:04p  CMON198B 019     1340  10-12-90   8:04p
CMON182A 019      1742  10-12-90   8:04p  CMON199  019     1848  10-12-90   8:04p
CMON183  019      2640  10-12-90   8:04p  CMON200  019     2376  10-12-90   8:04p
CMON183A 019      1675  10-12-90   8:04p  CMON200A 019     2345  10-12-90   8:04p
CMON184  019      3102  10-12-90   8:04p  CMON201  019     1980  10-12-90   8:04p
CMON191  019      1980  10-12-90   8:04p  CMON201A 019     3216  10-12-90   8:04p
CMON191A 019      1474  10-12-90   8:04p  CMON202  019     2244  10-12-90   8:04p
       26 File(s)    510976 bytes free
```

```
 Volume in drive B is MONITOR-87
 Directory of  B:\DIVE20

.            <DIR>     10-12-90   9:22p  CMON215A 020     1340  10-12-90   8:04p
..           <DIR>     10-12-90   9:22p  CMON216  020     1980  10-12-90   8:04p
CMON205  020      1386  10-12-90   8:04p  CMON219  020     2310  10-12-90   8:04p
CMON206  020      2112  10-12-90   8:04p  CMON220  020     2376  10-12-90   8:04p
CMON207  020      2178  10-12-90   8:04p  CMON221  020     1716  10-12-90   8:04p
CMON208  020      2706  10-12-90   8:04p  CMON223  020     1848  10-12-90   8:04p
CMON208A 020      1809  10-12-90   8:04p  CMON227  020     1320  10-12-90   8:04p
CMON209  020      2046  10-12-90   8:04p  CMON228  020     1386  10-12-90   8:04p
CMON210  020      2310  10-12-90   8:04p  CMON230  020     3762  10-12-90   8:04p
CMON210A 020      1675  10-12-90   8:04p  CMON233  020     2838  10-12-90   8:04p
CMON211A 020      1809  10-12-90   8:04p  CMON234  020     1584  10-12-90   8:04p
CMON215  020      1980  10-12-90   8:04p
       23 File(s)    510976 bytes free
```

```
 Volume in drive B is MONITOR-87
 Directory of  B:\DIVE21

.            <DIR>     10-12-90   9:22p  CMON249  021     2442  10-12-90   8:04p
..           <DIR>     10-12-90   9:22p  CMON251  021     2376  10-12-90   8:04p
CMON240  021      2442  10-12-90   8:04p  CMON252  021     3168  10-12-90   8:04p
CMON241  021      1914  10-12-90   8:04p  CMON253  021     3234  10-12-90   8:04p
CMON242  021      1848  10-12-90   8:04p  CMON255  021     3366  10-12-90   8:04p
CMON246  021      2376  10-12-90   8:04p  CMON257  021     2508  10-12-90   8:04p
CMON248  021      3498  10-12-90   8:04p
       13 File(s)    510976 bytes free
```

```
 Volume in drive B is MONITOR-87
 Directory of  B:\DIVE22

.            <DIR>     10-12-90   9:22p  CMON273  022     3102  10-12-90   8:04p
..           <DIR>     10-12-90   9:22p  CMON274  022     3300  10-12-90   8:04p
CMON264  022      4356  10-12-90   8:04p  CMON275  022     3036  10-12-90   8:04p
CMON265  022      3234  10-12-90   8:04p  CMON276  022     2772  10-12-90   8:04p
CMON266  022      2508  10-12-90   8:04p  CMON277  022     2970  10-12-90   8:04p
CMON268  022      3234  10-12-90   8:04p  CMON278  022     2376  10-12-90   8:04p
CMON269  022      3564  10-12-90   8:04p  CMON279  022     2838  10-12-90   8:04p
CMON270  022      3894  10-12-90   8:04p  CMON280  022     1452  10-12-90   8:04p
CMON271  022      3036  10-12-90   8:04p  CMON281  022     1716  10-12-90   8:04p
CMON272  022      3102  10-12-90   8:04p  CMON285  022      792  10-12-90   8:04p
       20 File(s)    510976 bytes free
```

Appendix E: Navigation Data Record Format

DSL PNS Format Description:

The DSL PNS navigation data record format is a variable length, ASCII record formatted as follows:

PNS Yr/Mo/Da Hr/Mn/Se.xx TYP CRD PLT EPos NPos Zpos Err Indic

where:

PNS - Record Acronym (Platform Navigation Status)

Yr/Mo/Da - Date of Fix as Year/Month/Day

Hr:Mn:Se.xx- Time of Fix as Hour:Minute:Seconds.xx

TYP - Navigation System Type (LBL for Long Base Line)

CRD - Coordinate System Type (NNE for Net Referenced East North Coordinates)

PLT - Platform (SHP for Ship, Veh or FSH for vehicle or towed platform)

EPos -East Position in meters

NPos - North Position in meters

ZPos - Z Position in meters (positive = increasing depth)

Err - Calculated Fix Positional Error (if available)

Indic - Additional Fix Indicator (usage varies by nav/data type)

In the final DSL PNS formatted navigation files produced for the *Monitor* data processing, the "Err" field is the number of transponders preserved from the unfiltered Oceano data files (NT field), and the "Indic" field is the sonar line number preserved from the sonar processing.

PNS, TYP, CRD, and PLT are always three-letter acronyms.

Date and Time are always as described with padded zeros.

Positional, err, and indic fields are variable length depending on the coordinate system in use and the actual usage of the err and indic fields.

NNE is a misnomer. It should be NEN; the data fields are always EAST,NORTH

Appendix F: Navigation File Start, End, Gaps

Dive 19

dsl_gap_check.awk v.17Sep90 run 1
checking cmon178.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 10:54:53.00 LBL NNE FSH 243.20 276.30 59.00 4.0 178
GAP #001 From:87/06/06 10:54:56.00 To:87/06/06 10:55:02.00 6 seconds
GAP #002 From:87/06/06 10:55:02.00 To:87/06/06 10:55:09.00 7 seconds
GAP #003 From:87/06/06 10:55:09.00 To:87/06/06 10:55:16.00 7 seconds
GAP #004 From:87/06/06 10:55:16.00 To:87/06/06 10:55:25.00 9 seconds
GAP #005 From:87/06/06 10:55:53.00 To:87/06/06 10:55:59.00 6 seconds
GAP #006 From:87/06/06 10:56:17.00 To:87/06/06 10:56:24.00 7 seconds
GAP #007 From:87/06/06 10:56:27.00 To:87/06/06 10:56:36.00 9 seconds
GAP #008 From:87/06/06 10:56:43.00 To:87/06/06 10:56:56.00 13 seconds
GAP #009 From:87/06/06 10:57:05.00 To:87/06/06 10:57:11.00 6 seconds
End rec: PNS 87/06/06 10:57:19.00 LBL NNE FSH 226.10 261.30 58.70 3.0 178
Nrecs proc: 35
Ngaps proc: 9

dsl_gap_check.awk v.17Sep90 run 2
checking cmon178a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 10:58:59.00 LBL NNE FSH 263.50 299.80 61.40 4.0 178a
GAP #001 From:87/06/06 11:00:18.00 To:87/06/06 11:00:24.00 6 seconds
GAP #002 From:87/06/06 11:01:11.00 To:87/06/06 11:01:17.00 6 seconds
GAP #003 From:87/06/06 11:01:45.00 To:87/06/06 11:01:55.00 10 seconds
GAP #004 From:87/06/06 11:02:57.00 To:87/06/06 11:03:04.00 7 seconds
End rec: PNS 87/06/06 11:03:37.00 LBL NNE FSH 225.90 257.00 58.10 4.0 178a
Nrecs proc: 86
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 3
checking cmon179.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:09:06.00 LBL NNE FSH 238.10 269.10 59.00 3.0 179
End rec: PNS 87/06/06 11:10:07.00 LBL NNE FSH 227.50 258.50 58.20 3.0 179
Nrecs proc: 21
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 4
checking cmon180.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:11:43.00 LBL NNE FSH 262.50 294.50 59.80 3.0 180
GAP #001 From:87/06/06 11:12:16.00 To:87/06/06 11:12:22.00 6 seconds
End rec: PNS 87/06/06 11:13:04.00 LBL NNE FSH 244.40 273.60 58.30 3.0 180
Nrecs proc: 27
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 5
checking cmon182.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:16:56.00 LBL NNE FSH 254.60 280.90 58.20 3.0 182
End rec: PNS 87/06/06 11:18:59.00 LBL NNE FSH 227.50 255.90 58.30 3.0 182
Nrecs proc: 41
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 6
checking cmon182a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:20:58.00 LBL NNE FSH 269.00 295.90 59.00 3.0 182a
End rec: PNS 87/06/06 11:22:14.00 LBL NNE FSH 251.10 276.90 59.00 3.0 182a
Nrecs proc: 27
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 7
checking cmon183.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:21:52.00 LBL NNE FSH 256.00 282.10 58.20 3.0 183
GAP #001 From:87/06/06 11:22:17.00 To:87/06/06 11:22:24.00 7 seconds
End rec: PNS 87/06/06 11:23:59.00 LBL NNE FSH 230.20 256.00 58.60 3.0 183
Nrecs proc: 41
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 8
checking cmon183a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:26:19.00 LBL NNE FSH 278.50 300.90 59.20 3.0 183a
GAP #001 From:87/06/06 11:26:19.00 To:87/06/06 11:26:25.00 6 seconds
GAP #002 From:87/06/06 11:26:46.00 To:87/06/06 11:26:52.00 6 seconds
End rec: PNS 87/06/06 11:27:37.00 LBL NNE FSH 258.80 282.80 58.90 3.0 183a
Nrecs proc: 26
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 9
checking cmon184.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 11:27:16.00 LBL NNE FSH 263.70 287.70 58.40 3.0 184
GAP #001 From:87/06/06 11:28:15.00 To:87/06/06 11:28:24.00 9 seconds
End rec: PNS 87/06/06 11:29:47.00 LBL NNE FSH 229.90 255.30 58.70 3.0 184
Nrecs proc: 48
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 10
checking cmon191.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 12:19:23.00 LBL NNE FSH 256.90 274.60 58.50 3.0 191
GAP #001 From:87/06/06 12:20:05.00 To:87/06/06 12:20:11.00 6 seconds
GAP #002 From:87/06/06 12:20:11.00 To:87/06/06 12:20:18.00 7 seconds
GAP #003 From:87/06/06 12:20:25.00 To:87/06/06 12:20:31.00 6 seconds
GAP #004 From:87/06/06 12:20:31.00 To:87/06/06 12:20:38.00 7 seconds

End rec: PNS 87/06/06 12:21:11.00 LBL NNE FSH 230.20 254.80 58.80 3.0 191
Nrecs proc: 31
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 11
checking cmon191a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 12:24:09.00 LBL NNE FSH 270.90 283.20 57.80 3.0 191a
GAP #001 From:87/06/06 12:25:10.00 To:87/06/06 12:25:16.00 6 seconds
End rec: PNS 87/06/06 12:25:16.00 LBL NNE FSH 255.70 273.60 58.20 3.0 191a
Nrecs proc: 23
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 12
checking cmon192.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 12:25:01.00 LBL NNE FSH 259.30 277.20 56.10 3.0 192
GAP #001 From:87/06/06 12:25:10.00 To:87/06/06 12:25:16.00 6 seconds
GAP #002 From:87/06/06 12:25:24.00 To:87/06/06 12:25:30.00 6 seconds
GAP #003 From:87/06/06 12:25:36.00 To:87/06/06 12:25:46.00 10 seconds
GAP #004 From:87/06/06 12:26:02.00 To:87/06/06 12:26:21.00 19 seconds
GAP #005 From:87/06/06 12:26:25.00 To:87/06/06 12:26:33.00 8 seconds
End rec: PNS 87/06/06 12:26:33.00 LBL NNE FSH 233.40 255.20 56.40 3.0 192
Nrecs proc: 20
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 13
checking cmon194.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 12:40:14.00 LBL NNE FSH 258.40 274.50 58.40 3.0 194
GAP #001 From:87/06/06 12:40:17.00 To:87/06/06 12:40:24.00 7 seconds
GAP #002 From:87/06/06 12:40:28.00 To:87/06/06 12:40:35.00 7 seconds
GAP #003 From:87/06/06 12:40:44.00 To:87/06/06 12:40:51.00 7 seconds
GAP #004 From:87/06/06 12:41:13.00 To:87/06/06 12:41:19.00 6 seconds
End rec: PNS 87/06/06 12:41:42.00 LBL NNE FSH 234.80 255.10 58.40 3.0 194
Nrecs proc: 25
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 14
checking cmon194a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 12:43:38.00 LBL NNE FSH 268.40 283.60 58.30 3.0 194a
GAP #001 From:87/06/06 12:43:38.00 To:87/06/06 12:43:44.00 6 seconds
GAP #002 From:87/06/06 12:44:23.00 To:87/06/06 12:44:29.00 6 seconds
GAP #003 From:87/06/06 12:44:32.00 To:87/06/06 12:44:38.00 6 seconds
End rec: PNS 87/06/06 12:44:54.00 LBL NNE FSH 260.20 274.30 58.20 3.0 194a
Nrecs proc: 24
Ngaps proc: 3

```
dsl_gap_check.awk v.17Sep90 run 15
checking cmon197.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 12:56:26.00 LBL NNE FSH 246.40 263.00 58.00 3.0 197
 GAP #001 From:87/06/06 12:56:47.00 To:87/06/06 12:56:54.00 7 seconds
 End rec: PNS 87/06/06 12:57:20.00 LBL NNE FSH 233.40 254.50 57.00 3.0 197
 Nrecs proc: 18
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 16
checking cmon198.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 13:01:27.00 LBL NNE FSH 264.30 276.30 54.90 3.0 198
 GAP #001 From:87/06/06 13:02:17.00 To:87/06/06 13:02:27.00 10 seconds
 End rec: PNS 87/06/06 13:03:16.00 LBL NNE FSH 236.80 253.80 56.20 3.0 198
 Nrecs proc: 34
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 17
checking cmon198a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 13:05:36.00 LBL NNE FSH 285.70 296.40 56.60 3.0 198a
 GAP #001 From:87/06/06 13:06:10.00 To:87/06/06 13:06:16.00 6 seconds
 End rec: PNS 87/06/06 13:08:29.00 LBL NNE FSH 235.00 250.80 53.80 3.0 198a
 Nrecs proc: 56
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 18
checking cmon198b.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 13:10:59.00 LBL NNE FSH 291.90 296.50 58.30 3.0 198b
 GAP #001 From:87/06/06 13:11:09.00 To:87/06/06 13:11:21.00 12 seconds
 End rec: PNS 87/06/06 13:12:10.00 LBL NNE FSH 269.90 277.00 57.30 3.0 198b
 Nrecs proc: 21
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 19
checking cmon199.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 13:12:30.00 LBL NNE FSH 263.50 271.60 55.70 3.0 199
 GAP #001 From:87/06/06 13:13:11.00 To:87/06/06 13:13:18.00 7 seconds
 End rec: PNS 87/06/06 13:14:00.00 LBL NNE FSH 239.50 252.20 56.50 3.0 199
 Nrecs proc: 29
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 20
checking cmon200.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
 Start rec: PNS 87/06/06 13:17:16.00 LBL NNE FSH 267.90 274.30 56.60 3.0 200
 End rec: PNS 87/06/06 13:19:06.00 LBL NNE FSH 238.90 250.20 55.70 3.0 200
 Nrecs proc: 37
 Ngaps proc: 0
```

dsl_gap_check.awk v.17Sep90 run 21
checking cmon200a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 13:20:57.00 LBL NNE FSH 279.30 289.50 56.50 3.0 200a
GAP #001 From:87/06/06 13:21:45.00 To:87/06/06 13:22:03.00 18 seconds
End rec: PNS 87/06/06 13:22:54.00 LBL NNE FSH 262.00 267.60 56.80 3.0 200a
Nrecs proc: 36
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 22
checking cmon201.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 13:22:42.00 LBL NNE FSH 265.70 270.90 56.50 3.0 201
End rec: PNS 87/06/06 13:24:13.00 LBL NNE FSH 240.40 250.70 55.50 3.0 201
Nrecs proc: 31
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 23
checking cmon201a.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 13:26:23.00 LBL NNE FSH 278.30 292.60 58.40 3.0 201a
GAP #001 From:87/06/06 13:26:41.00 To:87/06/06 13:26:47.00 6 seconds
GAP #002 From:87/06/06 13:26:56.00 To:87/06/06 13:27:05.00 9 seconds
GAP #003 From:87/06/06 13:27:14.00 To:87/06/06 13:27:20.00 6 seconds
GAP #004 From:87/06/06 13:27:26.00 To:87/06/06 13:27:32.00 6 seconds
GAP #005 From:87/06/06 13:27:53.00 To:87/06/06 13:28:00.00 7 seconds
GAP #006 From:87/06/06 13:28:00.00 To:87/06/06 13:28:09.00 9 seconds
GAP #007 From:87/06/06 13:28:42.00 To:87/06/06 13:28:51.00 9 seconds
End rec: PNS 87/06/06 13:29:15.00 LBL NNE FSH 265.80 270.00 55.90 3.0 201a
Nrecs proc: 49
Ngaps proc: 7

dsl_gap_check.awk v.17Sep90 run 24
checking cmon202.FSH.NAV.NNE.dive19 lowering dive19 for 5 second gaps
Start rec: PNS 87/06/06 13:29:06.00 LBL NNE FSH 268.50 271.90 56.10 3.0 202
GAP #001 From:87/06/06 13:29:15.00 To:87/06/06 13:29:21.00 6 seconds
GAP #002 From:87/06/06 13:29:31.00 To:87/06/06 13:29:37.00 6 seconds
GAP #003 From:87/06/06 13:29:55.00 To:87/06/06 13:30:01.00 6 seconds
GAP #004 From:87/06/06 13:30:13.00 To:87/06/06 13:30:19.00 6 seconds
GAP #005 From:87/06/06 13:30:32.00 To:87/06/06 13:30:38.00 6 seconds
GAP #006 From:87/06/06 13:30:51.00 To:87/06/06 13:30:58.00 7 seconds
End rec: PNS 87/06/06 13:31:07.00 LBL NNE FSH 240.80 249.70 55.10 3.0 202
Nrecs proc: 34
Ngaps proc: 6

dsl_gap_check.awk v.17Sep90 end processing 24 file(s) processed

Dive 20

dsl_gap_check.awk v.17Sep90 run 1
checking cmon205.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 14:44:50.00 LBL NNE FSH 265.80 268.80 56.00 4.0 205
GAP #001 From:87/06/06 14:44:50.00 To:87/06/06 14:44:57.00 7 seconds
GAP #002 From:87/06/06 14:44:57.00 To:87/06/06 14:45:04.00 7 seconds
GAP #003 From:87/06/06 14:45:27.00 To:87/06/06 14:45:37.00 10 seconds
End rec: PNS 87/06/06 14:46:09.00 LBL NNE FSH 241.30 248.80 55.80 4.0 205
Nrecs proc: 22
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 2
checking cmon206.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 14:51:26.00 LBL NNE FSH 281.90 280.40 55.50 3.0 206
GAP #001 From:87/06/06 14:51:50.00 To:87/06/06 14:51:59.00 9 seconds
GAP #002 From:87/06/06 14:53:00.00 To:87/06/06 14:53:06.00 6 seconds
End rec: PNS 87/06/06 14:53:17.00 LBL NNE FSH 244.10 249.30 55.70 3.0 206
Nrecs proc: 33
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 3
checking cmon207.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 14:56:08.00 LBL NNE FSH 278.60 276.80 58.30 3.0 207
GAP #001 From:87/06/06 14:56:20.00 To:87/06/06 14:56:29.00 9 seconds
GAP #002 From:87/06/06 14:57:42.00 To:87/06/06 14:57:49.00 7 seconds
GAP #003 From:87/06/06 14:58:00.00 To:87/06/06 14:58:07.00 7 seconds
End rec: PNS 87/06/06 14:58:07.00 LBL NNE FSH 244.80 247.90 55.70 3.0 207
Nrecs proc: 34
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 4
checking cmon208.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:00:36.00 LBL NNE FSH 282.50 277.80 57.80 3.0 208
GAP #001 From:87/06/06 15:00:54.00 To:87/06/06 15:01:00.00 6 seconds
GAP #002 From:87/06/06 15:01:07.00 To:87/06/06 15:01:13.00 6 seconds
GAP #003 From:87/06/06 15:02:49.00 To:87/06/06 15:02:55.00 6 seconds
End rec: PNS 87/06/06 15:02:55.00 LBL NNE FSH 246.40 248.60 55.80 3.0 208
Nrecs proc: 42
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 5
checking cmon208a.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:05:16.00 LBL NNE FSH 286.00 285.00 55.90 3.0 208a
GAP #001 From:87/06/06 15:05:58.00 To:87/06/06 15:06:04.00 6 seconds
GAP #002 From:87/06/06 15:06:13.00 To:87/06/06 15:06:20.00 7 seconds

End rec: PNS 87/06/06 15:06:43.00 LBL NNE FSH 270.30 266.80 57.00 3.0 208a
Nrecs proc: 28
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 6
checking cmon209.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:06:37.00 LBL NNE FSH 272.60 268.40 56.70 3.0 209
GAP #001 From:87/06/06 15:07:22.00 To:87/06/06 15:07:28.00 6 seconds
GAP #002 From:87/06/06 15:08:14.00 To:87/06/06 15:08:20.00 6 seconds
End rec: PNS 87/06/06 15:08:20.00 LBL NNE FSH 250.10 249.10 56.80 3.0 209
Nrecs proc: 32
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 7
checking cmon210.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:12:57.00 LBL NNE FSH 278.50 271.60 55.00 3.0 210
GAP #001 From:87/06/06 15:13:00.00 To:87/06/06 15:13:07.00 7 seconds
GAP #002 From:87/06/06 15:13:47.00 To:87/06/06 15:13:54.00 7 seconds
GAP #003 From:87/06/06 15:14:10.00 To:87/06/06 15:14:16.00 6 seconds
GAP #004 From:87/06/06 15:14:35.00 To:87/06/06 15:14:42.00 7 seconds
End rec: PNS 87/06/06 15:15:02.00 LBL NNE FSH 248.80 247.10 55.50 3.0 210
Nrecs proc: 36
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 8
checking cmon210a.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:17:42.00 LBL NNE FSH 289.00 287.60 56.00 3.0 210a
GAP #001 From:87/06/06 15:18:33.00 To:87/06/06 15:18:39.00 6 seconds
End rec: PNS 87/06/06 15:18:57.00 LBL NNE FSH 282.00 271.90 56.50 3.0 210a
Nrecs proc: 26
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 9
checking cmon211a.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:23:33.00 LBL NNE FSH 290.20 284.10 54.90 3.0 211a
End rec: PNS 87/06/06 15:24:53.00 LBL NNE FSH 274.60 265.80 56.50 3.0 211a
Nrecs proc: 28
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 10
checking cmon215.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:40:58.00 LBL NNE FSH 282.70 269.00 56.70 3.0 215
GAP #001 From:87/06/06 15:41:19.00 To:87/06/06 15:41:25.00 6 seconds
GAP #002 From:87/06/06 15:41:38.00 To:87/06/06 15:41:45.00 7 seconds
End rec: PNS 87/06/06 15:42:41.00 LBL NNE FSH 257.90 248.60 57.50 3.0 215
Nrecs proc: 31
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 11
checking cmon215a.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:44:22.00 LBL NNE FSH 293.00 278.60 58.70 3.0 215a
GAP #001 From:87/06/06 15:44:34.00 To:87/06/06 15:44:40.00 6 seconds
GAP #002 From:87/06/06 15:45:16.00 To:87/06/06 15:45:23.00 7 seconds
End rec: PNS 87/06/06 15:45:27.00 LBL NNE FSH 279.70 264.00 56.00 3.0 215a
Nrecs proc: 21
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 12
checking cmon216.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 15:45:19.00 LBL NNE FSH 283.00 266.80 56.80 3.0 216
End rec: PNS 87/06/06 15:46:55.00 LBL NNE FSH 259.60 248.20 56.70 3.0 216
Nrecs proc: 31
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 13
checking cmon219.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 16:21:02.00 LBL NNE FSH 280.00 259.90 56.20 3.0 219
GAP #001 From:87/06/06 16:22:21.00 To:87/06/06 16:22:36.00 15 seconds
GAP #002 From:87/06/06 16:22:55.00 To:87/06/06 16:23:06.00 11 seconds
End rec: PNS 87/06/06 16:23:12.00 LBL NNE FSH 256.50 237.80 55.60 3.0 219
Nrecs proc: 36
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 14
checking cmon220.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 16:29:17.00 LBL NNE FSH 290.70 267.10 55.20 3.0 220
GAP #001 From:87/06/06 16:29:32.00 To:87/06/06 16:29:38.00 6 seconds
GAP #002 From:87/06/06 16:30:11.00 To:87/06/06 16:30:18.00 7 seconds
End rec: PNS 87/06/06 16:31:21.00 LBL NNE FSH 262.90 245.30 55.80 3.0 220
Nrecs proc: 37
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 15
checking cmon221.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 16:34:28.00 LBL NNE FSH 289.20 264.60 54.20 3.0 221
End rec: PNS 87/06/06 16:35:50.00 LBL NNE FSH 265.90 245.60 56.00 3.0 221
Nrecs proc: 27
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 16
checking cmon223.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 16:49:12.00 LBL NNE FSH 293.30 265.70 56.10 3.0 223
GAP #001 From:87/06/06 16:49:28.00 To:87/06/06 16:49:38.00 10 seconds
GAP #002 From:87/06/06 16:49:38.00 To:87/06/06 16:49:44.00 6 seconds
End rec: PNS 87/06/06 16:50:50.00 LBL NNE FSH 266.90 243.00 56.40 3.0 223

Nrecs proc: 29
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 17
checking cmon227.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 17:08:17.00 LBL NNE FSH 266.00 256.50 56.50 3.0 227
End rec: PNS 87/06/06 17:09:15.00 LBL NNE FSH 250.80 246.80 57.00 3.0 227
Nrecs proc: 21
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 18
checking cmon228.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 17:13:42.00 LBL NNE FSH 272.80 261.60 55.90 3.0 228
End rec: PNS 87/06/06 17:14:44.00 LBL NNE FSH 256.70 243.40 56.70 3.0 228
Nrecs proc: 22
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 19
checking cmon230.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 18:26:30.00 LBL NNE FSH 264.10 290.20 59.00 3.0 230
GAP #001 From:87/06/06 18:26:33.00 To:87/06/06 18:26:39.00 6 seconds
GAP #002 From:87/06/06 18:26:39.00 To:87/06/06 18:26:45.00 6 seconds
GAP #003 From:87/06/06 18:28:43.00 To:87/06/06 18:28:50.00 7 seconds
GAP #004 From:87/06/06 18:28:50.00 To:87/06/06 18:29:03.00 13 seconds
GAP #005 From:87/06/06 18:29:35.00 To:87/06/06 18:29:41.00 6 seconds
End rec: PNS 87/06/06 18:29:50.00 LBL NNE FSH 219.80 253.00 58.40 3.0 230
Nrecs proc: 58
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 20
checking cmon233.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 18:46:17.00 LBL NNE FSH 256.50 275.90 57.90 3.0 233
GAP #001 From:87/06/06 18:46:45.00 To:87/06/06 18:46:52.00 7 seconds
GAP #002 From:87/06/06 18:46:52.00 To:87/06/06 18:46:58.00 6 seconds
End rec: PNS 87/06/06 18:48:40.00 LBL NNE FSH 230.60 255.80 57.10 3.0 233
Nrecs proc: 44
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 21
checking cmon234.FSH.NAV.NNE.dive20 lowering dive20 for 5 second gaps
Start rec: PNS 87/06/06 18:53:14.00 LBL NNE FSH 290.80 265.20 55.40 3.0 234
GAP #001 From:87/06/06 18:53:29.00 To:87/06/06 18:53:36.00 7 seconds
End rec: PNS 87/06/06 18:54:33.00 LBL NNE FSH 269.20 246.70 55.70 3.0 234
Nrecs proc: 24
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 end processing 21 file(s) processed

Dive 21

dsl_gap_check.awk v.17Sep90 run 1
checking cmon239.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 08:52:20.00 LBL NNE FSH 280.20 265.50 55.40 3.0 239
GAP #001 From:87/06/07 08:53:04.00 To:87/06/07 08:53:10.00 6 seconds
GAP #002 From:87/06/07 08:53:25.00 To:87/06/07 08:53:31.00 6 seconds
GAP #003 From:87/06/07 08:53:31.00 To:87/06/07 08:53:45.00 14 seconds
GAP #004 From:87/06/07 08:53:45.00 To:87/06/07 08:53:52.00 7 seconds
GAP #005 From:87/06/07 08:54:14.00 To:87/06/07 08:54:20.00 6 seconds
GAP #006 From:87/06/07 08:54:20.00 To:87/06/07 08:54:29.00 9 seconds
GAP #007 From:87/06/07 08:54:29.00 To:87/06/07 08:54:38.00 9 seconds
End rec: PNS 87/06/07 08:55:03.00 LBL NNE FSH 232.10 272.80 56.60 3.0 239
Nrecs proc: 41
Ngaps proc: 7

dsl_gap_check.awk v.17Sep90 run 2
checking cmon240.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:02:07.00 LBL NNE FSH 287.10 262.00 55.90 3.0 240
GAP #001 From:87/06/07 09:02:07.00 To:87/06/07 09:02:13.00 6 seconds
GAP #002 From:87/06/07 09:03:32.00 To:87/06/07 09:03:45.00 13 seconds
End rec: PNS 87/06/07 09:04:20.00 LBL NNE FSH 234.40 269.80 57.90 3.0 240
Nrecs proc: 38
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 3
checking cmon241.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:08:15.00 LBL NNE FSH 275.00 263.30 54.60 3.0 241
GAP #001 From:87/06/07 09:09:13.00 To:87/06/07 09:09:26.00 13 seconds
End rec: PNS 87/06/07 09:10:00.00 LBL NNE FSH 233.50 270.10 57.90 3.0 241
Nrecs proc: 30
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 4
checking cmon242.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:13:27.00 LBL NNE FSH 283.40 262.70 54.40 3.0 242
End rec: PNS 87/06/07 09:14:55.00 LBL NNE FSH 247.10 267.10 58.00 3.0 242
Nrecs proc: 29
Ngaps proc: 0

dsl_gap_check.awk v.17Sep90 run 5
checking cmon246.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:33:42.00 LBL NNE FSH 281.00 260.10 54.90 3.0 246
GAP #001 From:87/06/07 09:34:45.00 To:87/06/07 09:35:02.00 17 seconds
GAP #002 From:87/06/07 09:35:02.00 To:87/06/07 09:35:11.00 9 seconds
GAP #003 From:87/06/07 09:35:24.00 To:87/06/07 09:35:30.00 6 seconds

GAP #004 From:87/06/07 09:35:30.00 To:87/06/07 09:35:36.00 6 seconds
GAP #005 From:87/06/07 09:35:56.00 To:87/06/07 09:36:03.00 7 seconds
End rec: PNS 87/06/07 09:36:07.00 LBL NNE FSH 226.40 266.70 55.70 3.0 246
Nrecs proc: 37
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 6
checking cmon248.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:50:37.00 LBL NNE FSH 293.80 256.50 55.30 3.0 248
GAP #001 From:87/06/07 09:50:46.00 To:87/06/07 09:50:52.00 6 seconds
GAP #002 From:87/06/07 09:51:09.00 To:87/06/07 09:51:17.00 8 seconds
GAP #003 From:87/06/07 09:52:08.00 To:87/06/07 09:52:14.00 6 seconds
GAP #004 From:87/06/07 09:52:21.00 To:87/06/07 09:52:34.00 13 seconds
GAP #005 From:87/06/07 09:52:53.00 To:87/06/07 09:53:00.00 7 seconds
GAP #006 From:87/06/07 09:53:19.00 To:87/06/07 09:53:25.00 6 seconds
GAP #007 From:87/06/07 09:53:31.00 To:87/06/07 09:53:37.00 6 seconds
End rec: PNS 87/06/07 09:53:56.00 LBL NNE FSH 228.20 264.70 57.40 3.0 248
Nrecs proc: 54
Ngaps proc: 7

dsl_gap_check.awk v.17Sep90 run 7
checking cmon249.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 09:57:17.00 LBL NNE FSH 291.00 256.50 55.90 3.0 249
GAP #001 From:87/06/07 09:57:40.00 To:87/06/07 09:57:48.00 8 seconds
GAP #002 From:87/06/07 09:58:33.00 To:87/06/07 09:58:46.00 13 seconds
GAP #003 From:87/06/07 09:58:46.00 To:87/06/07 09:58:53.00 7 seconds
GAP #004 From:87/06/07 09:58:53.00 To:87/06/07 09:59:02.00 9 seconds
GAP #005 From:87/06/07 09:59:31.00 To:87/06/07 09:59:37.00 6 seconds
GAP #006 From:87/06/07 09:59:37.00 To:87/06/07 09:59:50.00 13 seconds
End rec: PNS 87/06/07 09:59:50.00 LBL NNE FSH 225.10 265.20 57.30 3.0 249
Nrecs proc: 38
Ngaps proc: 6

dsl_gap_check.awk v.17Sep90 run 8
checking cmon251.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 10:08:58.00 LBL NNE FSH 285.20 254.70 55.80 3.0 251
GAP #001 From:87/06/07 10:09:27.00 To:87/06/07 10:09:38.00 11 seconds
GAP #002 From:87/06/07 10:10:06.00 To:87/06/07 10:10:20.00 14 seconds
GAP #003 From:87/06/07 10:10:40.00 To:87/06/07 10:10:50.00 10 seconds
End rec: PNS 87/06/07 10:11:19.00 LBL NNE FSH 229.50 261.40 57.30 3.0 251
Nrecs proc: 37
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 9
checking cmon252.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 10:13:36.00 LBL NNE FSH 291.50 254.60 55.00 3.0 252

GAP #001 From:87/06/07 10:15:08.00 To:87/06/07 10:15:22.00 14 seconds
GAP #002 From:87/06/07 10:15:46.00 To:87/06/07 10:15:53.00 7 seconds
GAP #003 From:87/06/07 10:16:04.00 To:87/06/07 10:16:10.00 6 seconds
GAP #004 From:87/06/07 10:16:20.00 To:87/06/07 10:16:26.00 6 seconds
End rec: PNS 87/06/07 10:16:29.00 LBL NNE FSH 225.60 260.70 56.70 3.0 252
Nrecs proc: 49
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 10
checking cmon253.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 10:18:42.00 LBL NNE FSH 300.50 249.90 55.10 3.0 253
GAP #001 From:87/06/07 10:20:22.00 To:87/06/07 10:20:35.00 13 seconds
GAP #002 From:87/06/07 10:20:49.00 To:87/06/07 10:20:55.00 6 seconds
GAP #003 From:87/06/07 10:21:28.00 To:87/06/07 10:21:34.00 6 seconds
End rec: PNS 87/06/07 10:21:34.00 LBL NNE FSH 226.00 261.50 56.70 3.0 253
Nrecs proc: 50
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 11
checking cmon255.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 10:30:03.00 LBL NNE FSH 301.00 249.60 55.80 3.0 255
GAP #001 From:87/06/07 10:30:37.00 To:87/06/07 10:30:43.00 6 seconds
GAP #002 From:87/06/07 10:31:16.00 To:87/06/07 10:31:22.00 6 seconds
GAP #003 From:87/06/07 10:31:28.00 To:87/06/07 10:31:35.00 7 seconds
GAP #004 From:87/06/07 10:31:41.00 To:87/06/07 10:31:55.00 14 seconds
End rec: PNS 87/06/07 10:33:03.00 LBL NNE FSH 219.90 263.60 56.80 3.0 255
Nrecs proc: 52
Ngaps proc: 4
dsl_gap_check.awk v.17Sep90 run 12
checking cmon257.FSH.NAV.NNE.dive21 lowering dive21 for 5 second gaps
Start rec: PNS 87/06/07 10:44:58.00 LBL NNE FSH 289.50 250.40 54.60 3.0 257
GAP #001 From:87/06/07 10:45:11.00 To:87/06/07 10:45:24.00 13 seconds
GAP #002 From:87/06/07 10:46:19.00 To:87/06/07 10:46:33.00 14 seconds
GAP #003 From:87/06/07 10:46:33.00 To:87/06/07 10:46:40.00 7 seconds
GAP #004 From:87/06/07 10:46:56.00 To:87/06/07 10:47:08.00 12 seconds
GAP #005 From:87/06/07 10:47:21.00 To:87/06/07 10:47:28.00 7 seconds
End rec: PNS 87/06/07 10:47:37.00 LBL NNE FSH 223.50 259.40 57.90 3.0 257
Nrecs proc: 38
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 end processing 12 file(s) processed

Dive 22

dsl_gap_check.awk v.17Sep90 run 1
checking cmon264.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:05:11.00 LBL NNE FSH 296.60 263.80 55.90 3.0 264
GAP #001 From:87/06/07 13:05:32.00 To:87/06/07 13:05:38.00 6 seconds
GAP #002 From:87/06/07 13:07:03.00 To:87/06/07 13:07:17.00 14 seconds
GAP #003 From:87/06/07 13:07:48.00 To:87/06/07 13:07:55.00 7 seconds
GAP #004 From:87/06/07 13:08:04.00 To:87/06/07 13:08:10.00 6 seconds
End rec: PNS 87/06/07 13:08:57.00 LBL NNE FSH 229.40 270.90 57.50 3.0 264
Nrecs proc: 67
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 2
checking cmon265.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:12:41.00 LBL NNE FSH 289.40 264.00 55.30 3.0 265
GAP #001 From:87/06/07 13:14:04.00 To:87/06/07 13:14:18.00 14 seconds
GAP #002 From:87/06/07 13:14:32.00 To:87/06/07 13:14:39.00 7 seconds
GAP #003 From:87/06/07 13:15:01.00 To:87/06/07 13:15:07.00 6 seconds
GAP #004 From:87/06/07 13:15:17.00 To:87/06/07 13:15:23.00 6 seconds
End rec: PNS 87/06/07 13:15:38.00 LBL NNE FSH 230.90 270.40 57.60 3.0 265
Nrecs proc: 50
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 3
checking cmon266.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:18:34.00 LBL NNE FSH 281.40 263.10 55.40 3.0 266
GAP #001 From:87/06/07 13:19:32.00 To:87/06/07 13:19:46.00 14 seconds
GAP #002 From:87/06/07 13:19:57.00 To:87/06/07 13:20:04.00 7 seconds
GAP #003 From:87/06/07 13:20:07.00 To:87/06/07 13:20:13.00 6 seconds
GAP #004 From:87/06/07 13:20:32.00 To:87/06/07 13:20:38.00 6 seconds
GAP #005 From:87/06/07 13:20:38.00 To:87/06/07 13:20:48.00 10 seconds
End rec: PNS 87/06/07 13:21:04.00 LBL NNE FSH 226.80 271.10 56.20 3.0 266
Nrecs proc: 39
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 4
checking cmon268.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:30:58.00 LBL NNE FSH 287.90 261.30 55.40 3.0 268
GAP #001 From:87/06/07 13:32:38.00 To:87/06/07 13:32:51.00 13 seconds
GAP #002 From:87/06/07 13:33:00.00 To:87/06/07 13:33:06.00 6 seconds
GAP #003 From:87/06/07 13:33:16.00 To:87/06/07 13:33:22.00 6 seconds
GAP #004 From:87/06/07 13:33:22.00 To:87/06/07 13:33:29.00 7 seconds
End rec: PNS 87/06/07 13:33:53.00 LBL NNE FSH 229.10 268.50 56.50 3.0 268
Nrecs proc: 50
Ngaps proc: 4

dsl_gap_check.awk v.17Sep90 run 5
checking cmon269.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:37:01.00 LBL NNE FSH 288.40 259.70 56.10 3.0 269
GAP #001 From:87/06/07 13:38:25.00 To:87/06/07 13:38:39.00 14 seconds
GAP #002 From:87/06/07 13:38:49.00 To:87/06/07 13:38:55.00 6 seconds
GAP #003 From:87/06/07 13:39:44.00 To:87/06/07 13:39:54.00 10 seconds
End rec: PNS 87/06/07 13:40:13.00 LBL NNE FSH 228.10 267.60 56.50 3.0 269
Nrecs proc: 55
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 6
checking cmon270.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 13:44:48.00 LBL NNE FSH 286.60 259.70 55.50 3.0 270
GAP #001 From:87/06/07 13:46:22.00 To:87/06/07 13:46:35.00 13 seconds
GAP #002 From:87/06/07 13:46:35.00 To:87/06/07 13:46:42.00 7 seconds
GAP #003 From:87/06/07 13:47:13.00 To:87/06/07 13:47:19.00 6 seconds
GAP #004 From:87/06/07 13:47:35.00 To:87/06/07 13:47:41.00 6 seconds
GAP #005 From:87/06/07 13:48:11.00 To:87/06/07 13:48:17.00 6 seconds
End rec: PNS 87/06/07 13:48:17.00 LBL NNE FSH 226.60 268.80 57.60 3.0 270
Nrecs proc: 60
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 7
checking cmon271.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:05:53.00 LBL NNE FSH 287.80 258.90 55.30 3.0 271
GAP #001 From:87/06/07 14:06:05.00 To:87/06/07 14:06:12.00 7 seconds
GAP #002 From:87/06/07 14:06:24.00 To:87/06/07 14:06:35.00 11 seconds
GAP #003 From:87/06/07 14:07:11.00 To:87/06/07 14:07:25.00 14 seconds
GAP #004 From:87/06/07 14:07:48.00 To:87/06/07 14:07:55.00 7 seconds
GAP #005 From:87/06/07 14:08:04.00 To:87/06/07 14:08:11.00 7 seconds
GAP #006 From:87/06/07 14:08:31.00 To:87/06/07 14:08:37.00 6 seconds
End rec: PNS 87/06/07 14:08:56.00 LBL NNE FSH 220.20 268.90 58.30 3.0 271
Nrecs proc: 47
Ngaps proc: 6

dsl_gap_check.awk v.17Sep90 run 8
checking cmon272.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:13:18.00 LBL NNE FSH 282.20 257.80 55.80 3.0 272
GAP #001 From:87/06/07 14:13:45.00 To:87/06/07 14:13:51.00 6 seconds
GAP #002 From:87/06/07 14:14:29.00 To:87/06/07 14:14:43.00 14 seconds
GAP #003 From:87/06/07 14:14:56.00 To:87/06/07 14:15:05.00 9 seconds
GAP #004 From:87/06/07 14:15:05.00 To:87/06/07 14:15:12.00 7 seconds
GAP #005 From:87/06/07 14:16:03.00 To:87/06/07 14:16:12.00 9 seconds
End rec: PNS 87/06/07 14:16:15.00 LBL NNE FSH 225.80 265.50 55.60 3.0 272
Nrecs proc: 48
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 9
checking cmon273.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:19:26.00 LBL NNE FSH 284.40 256.90 55.00 3.0 273
GAP #001 From:87/06/07 14:20:35.00 To:87/06/07 14:20:49.00 14 seconds
End rec: PNS 87/06/07 14:22:07.00 LBL NNE FSH 226.20 263.40 55.60 3.0 273
Nrecs proc: 48
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 10
checking cmon274.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:24:36.00 LBL NNE FSH 291.50 255.30 55.50 3.0 274
GAP #001 From:87/06/07 14:26:03.00 To:87/06/07 14:26:16.00 13 seconds
GAP #002 From:87/06/07 14:26:32.00 To:87/06/07 14:26:38.00 6 seconds
GAP #003 From:87/06/07 14:27:19.00 To:87/06/07 14:27:25.00 6 seconds
End rec: PNS 87/06/07 14:27:28.00 LBL NNE FSH 225.60 263.50 55.90 3.0 274
Nrecs proc: 51
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 11
checking cmon275.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:30:37.00 LBL NNE FSH 291.60 253.40 56.00 3.0 275
GAP #001 From:87/06/07 14:31:14.00 To:87/06/07 14:31:20.00 6 seconds
GAP #002 From:87/06/07 14:32:04.00 To:87/06/07 14:32:19.00 15 seconds
GAP #003 From:87/06/07 14:32:25.00 To:87/06/07 14:32:33.00 8 seconds
GAP #004 From:87/06/07 14:32:33.00 To:87/06/07 14:32:39.00 6 seconds
GAP #005 From:87/06/07 14:32:55.00 To:87/06/07 14:33:01.00 6 seconds
GAP #006 From:87/06/07 14:33:01.00 To:87/06/07 14:33:08.00 7 seconds
GAP #007 From:87/06/07 14:33:24.00 To:87/06/07 14:33:31.00 7 seconds
End rec: PNS 87/06/07 14:33:31.00 LBL NNE FSH 226.40 262.40 56.10 3.0 275
Nrecs proc: 47
Ngaps proc: 7

dsl_gap_check.awk v.17Sep90 run 12
checking cmon276.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:36:48.00 LBL NNE FSH 286.30 255.20 56.30 3.0 276
GAP #001 From:87/06/07 14:38:03.00 To:87/06/07 14:38:21.00 18 seconds
GAP #002 From:87/06/07 14:38:40.00 To:87/06/07 14:38:47.00 7 seconds
GAP #003 From:87/06/07 14:39:00.00 To:87/06/07 14:39:06.00 6 seconds
End rec: PNS 87/06/07 14:39:25.00 LBL NNE FSH 228.20 260.80 57.40 3.0 276
Nrecs proc: 43
Ngaps proc: 3

dsl_gap_check.awk v.17Sep90 run 13
checking cmon277.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:42:51.00 LBL NNE FSH 289.10 252.30 55.50 3.0 277
GAP #001 From:87/06/07 14:43:22.00 To:87/06/07 14:43:28.00 6 seconds

GAP #002 From:87/06/07 14:44:09.00 To:87/06/07 14:44:25.00 16 seconds
GAP #003 From:87/06/07 14:44:42.00 To:87/06/07 14:44:48.00 6 seconds
GAP #004 From:87/06/07 14:45:07.00 To:87/06/07 14:45:13.00 6 seconds
GAP #005 From:87/06/07 14:45:30.00 To:87/06/07 14:45:37.00 7 seconds
End rec: PNS 87/06/07 14:45:37.00 LBL NNE FSH 225.00 261.40 55.90 3.0 277
Nrecs proc: 46
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 14
checking cmon278.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 14:57:26.00 LBL NNE FSH 290.40 250.90 55.60 3.0 278
GAP #001 From:87/06/07 14:58:29.00 To:87/06/07 14:58:43.00 14 seconds
GAP #002 From:87/06/07 14:59:02.00 To:87/06/07 14:59:09.00 7 seconds
End rec: PNS 87/06/07 14:59:37.00 LBL NNE FSH 225.40 261.90 56.40 3.0 278
Nrecs proc: 37
Ngaps proc: 2

dsl_gap_check.awk v.17Sep90 run 15
checking cmon279.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 15:05:13.00 LBL NNE FSH 281.90 250.20 55.90 3.0 279
GAP #001 From:87/06/07 15:05:13.00 To:87/06/07 15:05:23.00 10 seconds
GAP #002 From:87/06/07 15:05:52.00 To:87/06/07 15:06:01.00 9 seconds
GAP #003 From:87/06/07 15:06:10.00 To:87/06/07 15:06:17.00 7 seconds
GAP #004 From:87/06/07 15:06:51.00 To:87/06/07 15:07:05.00 14 seconds
GAP #005 From:87/06/07 15:07:31.00 To:87/06/07 15:07:37.00 6 seconds
End rec: PNS 87/06/07 15:08:00.00 LBL NNE FSH 235.40 255.50 56.20 3.0 279
Nrecs proc: 44
Ngaps proc: 5

dsl_gap_check.awk v.17Sep90 run 16
checking cmon280.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 15:11:27.00 LBL NNE FSH 278.80 250.20 55.30 3.0 280
GAP #001 From:87/06/07 15:12:16.00 To:87/06/07 15:12:36.00 20 seconds
End rec: PNS 87/06/07 15:12:56.00 LBL NNE FSH 239.20 255.60 55.50 3.0 280
Nrecs proc: 23
Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 run 17
checking cmon281.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
Start rec: PNS 87/06/07 15:16:22.00 LBL NNE FSH 277.90 248.80 57.10 2.0 281
GAP #001 From:87/06/07 15:16:29.00 To:87/06/07 15:16:35.00 6 seconds
GAP #002 From:87/06/07 15:16:44.00 To:87/06/07 15:16:51.00 7 seconds
GAP #003 From:87/06/07 15:17:04.00 To:87/06/07 15:17:17.00 13 seconds
GAP #004 From:87/06/07 15:17:57.00 To:87/06/07 15:18:05.00 8 seconds
End rec: PNS 87/06/07 15:18:05.00 LBL NNE FSH 237.40 254.50 53.20 2.0 281
Nrecs proc: 27
Ngaps proc: 4

```
dsl_gap_check.awk v.17Sep90 run 18
checking cmon285.FSH.NAV.NNE.dive22 lowering dive22 for 5 second gaps
 Start rec: PNS 87/06/07 15:22:32.00 LBL NNE FSH 252.30 253.10 57.90 3.0 285
 GAP #001 From:87/06/07 15:23:00.00 To:87/06/07 15:23:09.00 9 seconds
 End rec: PNS 87/06/07 15:23:15.00 LBL NNE FSH 225.30 263.50 58.70 2.0 285
 Nrecs proc: 12
 Ngaps proc: 1

dsl_gap_check.awk v.17Sep90 end processing 18 file(s) processed
```